is, pulse oximetry. Strong encouragement to include continuous end-tidal carbon dioxide measurement as a standard should lead to its adoption soon. Certainly other monitoring capabilities will be included as technology makes them available.

During the past three years similar standards for all anesthetics have been adopted in New Jersey, New York, and Massachusetts, and many other states are currently contemplating their own standards. The ASA has attempted to work closely with the legislatures to make this legislation acceptable on a practical and medicolegal basis.

Have these standards improved patient safety? Malpractice carriers seem to think they are beneficial because several gave immediate discounts to anesthesiologists adopting these standards. In addition, anesthesiology may be the only medical specialty to see its malpractice rates drop during the past several years as insurance companies downgraded its risk category. During this time, critics point out, newer anesthesia equipment has been introduced, better-trained anesthesia personnel have entered practice, and safer drugs have been developed. What effect each of these factors has had on patient safety is not certain, but preliminary data through 1988 since Harvard adopted its monitoring standards have shown a trend toward a 70% reduction in preventable anesthetic accidents. Anesthesia monitoring standards are clearly here to stay, and specific practice standards will continue to be added in the future.

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Noninvasive Cardiac Output Measurement

THERMODILUTION CARDIAC OUTPUT is often measured to evaluate heart function in critically ill patients or patients undergoing a major operation. Pulmonary artery catheterization, which is required to measure the thermodilution cardiac output, has potentially serious complications, such as malignant arrhythmia, pneumothorax, and even death. It has recently been proposed that these risks do not outweigh the benefits of pulmonary catheterization. Thus, noninvasive cardiac output measurement techniques become attractive if they can provide some benefits of pulmonary artery catheterization—that is, cardiac output measurement—with reduced patient risk.

Two types of noninvasive cardiac output measurement are currently available: thoracic bioimpedance and Doppler ultrasonography. In thoracic bioimpedance, electrodes are placed on the patient's neck and thorax, and a high-frequency microcurrent is injected into one set of electrodes, with differences in the current detected by another electrode set. Pulsatile changes in the thoracic electrical resistance (impedance) are attributed to cardiac systole and used to calculate the stroke volume. Doppler ultrasonography measures cardiac output by measuring aortic blood velocity. The integral of the aortic blood velocity during systole, when multiplied by the cross-sectional area of the aorta, yields the stroke volume. Ascending aortic blood velocity can be measured at the suprasternal notch and inside the trachea (at the tip of an endotracheal tube). Descending aortic blood velocity can be measured from the esophagus (at the tip of an esophageal probe).

Each noninvasive method has different advantages and disadvantages. Bioimpedance electrodes are easily applied and can provide continuous estimates of cardiac output but are sensitive to electrical interference. Doppler techniques generally measure the aortic blood velocity well, but their absolute accuracy depends on knowing the aortic cross-sectional area. Using a cross-sectional aortic area derived from a nomogram decreases the accuracy, and measuring the aortic diameter with other techniques such as two-dimensional or M-mode echocardiography requires highly skilled examiners. Further, the cross-sectional area of the aorta may not be constant.

Thoracic bioimpedance, esophageal Doppler, and transtracheal Doppler can measure the cardiac output continuously, but suprasternal Doppler can measure cardiac output only intermittently. Both techniques have variable agreement with thermodilution. Some of the difference between thermodilution and the noninvasive methods may be due to a variability in the thermodilution measurement itself rather than the noninvasive measurement.

In their current form, neither bioimpedance nor Doppler ultrasonography can totally replace thermodilution cardiac output measurement. It is hoped they will either prove to be useful in following trend changes in cardiac output or that their technology will be further improved until they can be substituted for thermodilution cardiac output measurements.

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Transdermal-Mucosal Sedative and Analgesic Delivery

ALTHOUGH THE SKIN AND MUCOSAL MEMBRANES of the mouth and nose have long been used for drug delivery, until recently these sites had been overlooked as locations for administering analgesic and sedative-hypnotic drugs. In the past few years, however, research and clinical testing of nonparenteral, noninvasive routes of anesthetic delivery have been active. New vehicles including skin patches, nasal sprays, buccal tablets, and lozenges on a handle have been developed to enable the safe, simple, and efficacious delivery of transdermal and transmucosal anesthetics. Certain patient groups such as children will benefit from these new technologies because an intravenous or intramuscular injection will no longer be necessary for the delivery of potent anesthetics and analgesics. Patient compliance may be greatly improved—compared with that with orally ingested pills—as sustained-release systems using transdermal and transmucosal delivery permit less-often dosing schedules. The clinical application of transdermal and transmucosal anesthetic and analgesic systems includes preoperative sedation and lessening of anxiety, acute postoperative analgesia, and the treatment of chronic pain.

The preoperative administration of sufentanil citrate or midazolam hydrochloride nasal aerosols to children is a simple, relatively pain-free method of reducing the stress